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# DIAGNOSTIC CIRCUIT FOR A TREBLE LOUDSPEAKER OF A LOUDSPEAKER COMBINATION

The invention relates to a diagnostic circuit for a treble loudspeaker of a loudspeaker combination, as well as a method for testing a treble loudspeaker of a loudspeaker combination.

In low-frequency output stages of loudspeaker systems that are provided, for example, in a motor vehicle, a bass and a midtone loudspeaker, or a midtone/bass loudspeaker, are generally connected directly to the amplifiers of the low-frequency output stages, and a treble loudspeaker is coupled capacitatively. The functionality of this loudspeaker combination is tested in particular upon installation into a vehicle, and as applicable at maintenance intervals or in the event of malfunctions. Interruptions or short circuits in the supply leads may, in particular, occur in this context. Testing of the bass, midtone, or midtone/bass loudspeakers can be accomplished directly in resistive fashion using an applied DC voltage. A corresponding testing of the capacitatively connected treble loudspeaker is, however, not thereby possible. This testing is accordingly usually performed by input of a treble signal and acoustic perception. Such testing is, however, time-consuming and imprecise in the context of automated production.

Also known are circuit assemblages in which the current consumption of an output stage IC is measured upon application of a high LF frequency and a high output level. For this purpose, a measurement device must be appropriately

provided in the power supply to the power output stages.

The diagnostic circuit according to the present invention as defined by Claim 1 and the method according to the present invention as defined in Claim 13 have, in contrast, the particular advantage that an accurate measurement of the functionality of a treble loudspeaker of a loudspeaker combination is possible with relatively little complexity. The dependent claims describe preferred refinements.

According to the present invention, testing of the treble loudspeaker is thus made possible by the fact that a voltage divider circuit is constituted from a preferably purely ohmic resistor and the loudspeaker combination, and a voltage drop within that voltage divider circuit is measured and evaluated. In particular, the voltage drop can be measured in this context as a complex measured voltage at the loudspeaker combination; in principle, however, a measurement of the voltage drop at the measuring resistor is also possible.

In the voltage divider circuit, the bass, midtone, or midtone/bass loudspeaker or loudspeakers are connected in parallel with the coupling capacitor and the treble loudspeaker. The functionality or condition of the treble loudspeaker affects the complex total resistance of the loudspeaker combination at the HF frequency. An interruption at the treble loudspeaker or its supply leads results in an increase in the total resistance, and a short circuit correspondingly in a decrease in the total resistance, as compared with the total resistance when the treble loudspeaker is functional. Since the loudspeakers designed for lower frequencies have a higher inductance than the treble loudspeaker, they have little influence on the measured signal.

The measured complex measured voltage can be evaluated, for example, by measuring the peak value phase-shifted with respect to the output signal, or by way of a rectifier circuit.

The invention will be explained below, in several embodiments, with reference to the attached drawings, in which:

Figure 1 is a block diagram of a power output stage having a diagnostic circuit according to a first embodiment of the invention;

Figure 2 is a block diagram of a power output stage having a diagnostic circuit according to a second embodiment of the invention.

As shown in Figure 1, a first output amplifier V1 of a low-frequency output stage is connected via a first terminal A1 to the positive pole on loudspeaker combination 4, and a second output amplifier V2 of the low-frequency output stage is connected via a second terminal A2 to the negative pole of loudspeaker combination 4. Loudspeaker combination 4 has a midtone/bass loudspeaker LS1 that is connected to terminals A1, A2, and a treble loudspeaker LS2 connected via a capacitor C7 in parallel with LS1. For diagnosis of treble loudspeaker LS2, loudspeakers LS1 and LS2 are activated and amplifiers V1, V2 are switched off and are thus high-resistance. A processor 10 outputs an HF input signal s1 that is outputted via an impedance converter 3 as HF voltage signal s2. Processor 10 thus constitutes, with impedance converter 3, an HF voltage-generating device 2. HF input signal s1 is transferred through a resistor R2 and a capacitor C4 to first terminal A1, i.e. to the positive pole of loudspeaker combination 4. Second terminal A2 is grounded

through a connecting device 6. At A1, the voltage drop at loudspeaker combination 4 and at connecting device 6 is picked off by a measurement device 11 as complex measured voltage UA1.

In HF voltage-generating device 2, HF input signal s1 having a frequency greater than or equal to 20 KHz, and a diagnostic signal d constituting a DC voltage signal, are outputted by processor 10. Diagnostic signal d sets a diagnostic mode. Processor 10 also (in a manner not shown) switches output amplifiers V1, V2 to high resistance by way of diagnostic signal d. HF voltage signal s is conveyed through a capacitor C2, together with diagnostic signal d, to an emitter follower transistor V3 of impedance converter 3, the working point of the base of emitter follower transistor V3 being set by way of resistors R4, R6. A further transistor V4 and a resistor R3 constitute a constant-current source connected to the emitter of V3, V4 being made conductive upon application of diagnostic signal d to its base. Impedance converter 3 outputs an HF voltage signal S2 that drops to ground through measuring resistor R2, capacitor C4, loudspeaker combination 4, and connecting device 6.

Connecting device 6 has a transistor V5 that is modulated by diagnostic signal d and connects an AC voltage present at second terminal A2 to ground in low-resistance fashion. With suitable dimensioning of capacitors C4, C7, HF voltage signal S2 thus drops substantially at a series circuit of R2 and the parallel-connected loudspeakers LS1 and LS2.

Measured voltage UA1 present at A1 is received by a measurement device 11 that is constituted by a resistor R1, a capacitor C8, and processor 10 that serves as the evaluation device. Measured voltage UA1 is phase-shifted

with respect to S1, in particular because of the impedances of LS1 and LS2. In the embodiment shown in Figure 1, the phase-shifted peak value is determined by measurement device 11, and because R2 is known, the impedance of loudspeaker combination 4 is ascertained therefrom. Since LS1 has a high inductance, the voltage drop between A1 and A2 is determined substantially by LS2. Measurement device 11 thus identifies a low measured voltage (or a measured voltage with a low absolute value) in the event of a short circuit, a high measured voltage in the event of an interruption at LS2, and a moderate measured voltage when LS2 is in the functional condition.

In the embodiment shown in Figure 2, unlike in the first embodiment, a measurement device 12 is used in which a resistor R1, capacitor C7, a Schottky diode D1, and a grounded capacitor C1 serve to rectify the received AC voltage signal, so that processor 10 can receive a rectified voltage.